Residential Gateway for Electricity Response: Resolve of Customer Access, System Expansion, Market Manipulation, and Environmental Goals

Abstract: Designers of competitive electricity systems face numerous challenges regarding how to achieve efficient retail customer access, cost-containment, market power mitigation, and environmental goals. The ideal system would provide retail price and demand response, customer satisfaction, meet environmental objectives, be highly reliable, and provide appropriate investment signals for system expansion. Starting in Chicago, the *WattSpot* residential, real-time interactive gateway is designed to resolve these challenges. It facilitates web-based, automated customer choice based on hourly electricity metering and prices, demand response and energy efficiency options, environmental dispatch, and highly interactive customer education. Research is presented to show how this gateway and the related data can be used resolve critical challenges to competitive electricity markets and leverage customer options.

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Introduction

In theory, a competitive market is where buyers and sellers can agree on price, but currently those that make and transmit electricity have advantage. This is because most customers have little idea how electricity is priced and are not educated about how to lower their costs. Customers' lack of knowledge about electricity prices is the major barrier to use of real-time-pricing (RTP) and its variant, time-of use (TOU) pricing (Hirst 2002). This paper explains how an internet gateway enables residential customers to avoid the constraints of average electricity pricing, use the competitive market, take actions to lower electricity bills, reduce overall electricity system costs, mitigate the exercise of market power, and reduce environmental pollution.[3] Notably, small customer reductions in electricity demand can dramatically lower energy bills during high priced times. This electronic gateway enables customer access to electricity information and meaningful energy options to resolve important electricity industry issues.

Competitive electricity markets across the globe face major issues with customer services, access to information, demand response and energy efficiency, resource adequacy, appropriate system expansion (including which resource to site and where), exercise of market power, and environmental degradation (Joskow 2006, Kwoka 2006). Notably, major tradeoffs among goals related to financial results, consumer protection, reliability, least-cost expansion, and environmental protection have been difficult to resolve. Electronic communication and digital access present opportunities to offer new customer services and data that enable greater resolve of these difficult tradeoffs. Thus, this research shows how RTP and TOU programs can be provided to capture the hypothesized benefits of retail competition (Rassenti, Smith, and Wilson 2002).

Supply-Side Dominance – Not Least-Cost

Reserve margins for reliability are declining across the U.S., leaving questions about whether supply-side resources will come on-line quickly enough to avoid major reliability problems (NERC 2006). Dominated by supply-side thinking, the electricity industry has promoted power generation and transmission over customer demand response and energy efficiency – the demand side alternatives – until recently[4]. In the

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[3] The average Chicago summer price last year was 8.25 cents a kilowatt-hour, though the peak price was as much as 36.5 cents a kilowatt-hour, and on 38 days last year power cost less than a cent per kWh. David Cay Johnston, New York Times, *Taking Control of Electricity Bill, Hour-By-Hour*, 8 January 2007.
[4] See statistics on recent demand side efforts at http://www.eia.doe.gov/cneaf/electricity/epa/epat9p1.html.

absence of customer participation or demand side alternatives wholesale competitive electricity markets have been governed by supply-side bidding and pricing. As a result, the electricity supply industry has largely had its way in terms of pricing during periods of high demand and when major plant or transmission outages occur (Joskow 2006). Efforts are being made to better balance electricity resource portfolios. Still, though demand response can be provided quickly at lower costs it use remains largely nascent.

With wholesale unbundling of electricity supply from transmission and distribution, these separate business units become competitive, at tension with demand response providers. Retail competition, to acquire and serve customers directly, as well places demand response providers at odds. Wholesale and retail unbundling result in a fractured value chain for those who seek to monetize the full benefits of demand response across separately unbundled entities. Hence, retail providers of demand-response have difficulty marketing its full benefits. With this gap, distribution and transmission companies gain benefits by installing more of their respective resources, as do generation providers, and so actively resist use of demand side resources. These non-market impacts, thus, directly reduce the viability of and the use of demand response.

Current Resource Expansion Compared to Optimal Expansion

Resource expansion, to add the electricity facilities to meet growing demand, presents tensions that stem largely from the financial incentives inherent in regulated investor-owned utilities. Regulated distribution and transmission (T&D) utilities have strong incentives to expand the construction and use of these resources, as expansion directly increases earnings with little accompanying risk.[5] On the other hand, demand side resources result in less need for T&D and reduced electrical loadings on those systems. Owners of T&D and generation resources have large existing investments in place, are large stakeholders and accordingly hold substantial sway in resource allocation decisions in regulatory proceedings. Regulators and consumer groups remain the primary supporters of demand side resources. The optimal resource expansion level is based on building out the system under least-cost principles until the incremental costs of the next resource addition is equal to the incremental value of electricity to that customer group. That is, build out the system only to the level that customers are willing to pay for the electricity received. Without customer response to electricity prices, however, it is difficult to determine the incremental value of electricity service – the optimal cost level – that is appropriate. This suggests fundamentally that a large number of customers should be given the opportunity to choose the level at which they are willing to pay for electricity, and correspondingly the opportunity to turn off electricity use when prices remain too high. This will then lead to more optimal determination of the level of resource expansion that is appropriate.

Retail Choice – Matters of Degree

If customers can select from competing retail access providers, they have choice of suppliers given that meaningful differences in electricity costs exist. Most consumers have been offered demand side options by utilities.[6] Even with these choices and where wholesale competition exists, however, most retail customers merely consume electricity

[5] This results from *rate-base* growth; as more T&D facilities are installed regulated company profits grow.
[6] These are usually energy efficiency measures, such as water heater blankets, insulation, and the like.

and pay the bill. New *interval* electricity meters are being installed in many areas to tally electricity use during short intervals, such as every 15 minutes. These meters provide consumers with a window into their actual time-based electricity use. Most people do not know that electricity prices vary substantially throughout the day, especially during peak load times. With knowledge of the cost consequences, especially during high price periods, customers are more motivated and will respond. With knowledge of actual electricity prices, consumers can shift usage, achieve conservation, provide demand response, and save money (Kiesling 2006). In response to Enron style market games, RTP and TOU pricing reduce the potential for market manipulation (Woychik 2007).[7]

The WattSpot RTP program extends customer choice to enable hour-to-hour decisions to increase (decrease) electricity use. An electronic gateway is created for customers to obtain hourly prices, demand side options, and web-programmable options to lower electricity bills. Wholesale hourly electricity prices that may fluctuate greatly are passed on to retail customers who then have the opportunity to lower their bills. With a flip of the switch, albeit possibly automated, customers can change their electricity use in response to electronic messages that indicate high prices, such as during summer heat storms. For example, when the electricity price hits $0.35/kWh to $0.50/kWh, a set of appliances can be turned off to lower bills, or not turned on to control bills. Automation technology such as a smart, programmable thermostat (T-Stat) can greatly benefit customers and signal when to turn off air-conditioning or water heating, possibly at pre-determined electricity prices or time periods. Much more than these basic choices, a set of services available under the WattSpot Residential Gateway are summarized in Table 1.

Table 1: WattSpot Residential Gateway Services

GATEWAY WEB SERVICES – THE *WATTSPOT* PROGRAM
Customer Enrollment: to sign up, obtain interval metering, and see real-time prices
Quick Enrollment Survey for Declining Participants
Interactive Customer Education, Training & Feedback
Electricity Service Disconnect/Reconnect
View Next Day Hourly Prices
Email Notice & Assistance to Customers
Presentment of Historic Billing Information
Graphical Energy Use Analysis Tools
In-depth Participation Feedback Forms
Energy Saving Scenario Modeling
Rate-Guard Protection With Device-Based Control (including enrollment)
Nature-First Air Conditioner Cycling (including enrollment)
Access to Thermostat Set-points & Offsets for Price-Response Control
Access to Home Energy Audit Program (including enrollment)
Access to WattSpot, Energy Doctor, and Online Energy Store

[7] The reduction of electric market manipulation is one or FERC's top priorities. See http://www.ferc.gov/legal/maj-ord-reg/land-docs/order670.asp.

Importantly, consumer friendly technology, such as air-conditioner cycling and automated appliance switching, reduce the hassle-factor for customers. Some customers may seek more active strategies to *follow the meter* and both lower and increase electricity use with changes in hourly electricity prices. Notices of high electricity price periods can also be used to alert customers. Beyond this the electronic gateway presents more options than mere choice of price-points or choice of retail service providers. Innovations to the WattSpot RTP program are ongoing and will be added over time. *Nature First* currently provides air-conditioner cycling that can be controlled to dispatch demand response during peak periods. *Rate Guard* provides automatic pricing control thresholds for thermostat and appliance switch control. Price thresholds can be changed by the customer at the thermostat or through the web-based gateway. A third innovation is *Environmental Dispatch* for customers that seek to provide environmental benefits by reducing their use of specific electricity uses in order to reduce power plant emissions (e.g., SOx, NOx, and CO2). Both *Nature First* and *Rate Guard* reduce power plant emissions considerably during times when less efficient, more polluting plants are operating. Many other technology-based choices will undoubtedly be offered.

Results with RTP

The RTP mass market program was tested in 2005 using a pool of 1,500 customers in Chicago. Econometric modeling to estimate the price elasticity effects indicate an overall reduction in hourly electricity demand of 4.7 percent, and an additional 2.2 percent reduction in demand for customers that used the Nature First air conditioner cycling program. (Summit 2006) Hence, a doubling of electricity prices will decrease hourly demand by approximately 6.9 percent. This assumes that customer notification occurs of impending high prices (over $0.10/kWh). Customer education and training, as well as automated technology to reduce customer hassle-factor, are especially effective to increase price elasticity of demand. The energy conservation effect also estimated produced a 3 to 4 percent reduction for RTP customers compared to those on the basic electricity rate. In 2007, the WattSpot residential RTP program will rely on Day-Ahead prices from the PJM electricity market. Because these are more volatile prices greater customer response to prices is expected. Results of the California Statewide pricing Project summarized by Ahmad Faraqui and Steve George show that residential customers reduce hourly peak electricity use up to 13.1 percent in response to prices that peaked at $0.59/kWh (Faraqui and George 2006, pg. 59). Related studies of residential and larger customers indicated RTP programs that index to Day Ahead prices provide customers with more compelling and more stable incentives for price response than do RTP programs indexed to real-time market prices (Barbos, *et al*. 2006, Hopper, *et al*. 2006). Likewise, data from the TOU program at Gulf Power indicates that with major differences in posted prices and customer notification of high price times that customer response substantially reduces peak load.

Implications of the Residential RTP Gateway

The implications of the WattSpot RTP program and its additional innovations are substantial. First, it should be noted that the WattSpot Gateway is the first actively marketed residential internet portal to provide for new interval electricity metering, electricity market prices, and an extended array of energy services. Second, this is the

only major program of this scale that indicates how much electricity is desired by customers in relation to the hourly price they are willing to pay for it. Ultimately, it will answer the primary question, what is the optimal level of electricity reliability such that its cost and quantity equal the value that customers place on it? Third, this program is available through web-site sign-up and interface, to allow customers to change their electricity use preferences as circumstances in their lives change, and allows customers to change their preferences back again on-line. Fourth, it enables customer selection of content, including specific options such as *Nature First, Rate Guard, Environmental Dispatch*, and other energy education, energy efficiency, and demand side services. Fifth, based on price levels customers will act directly to reduce the need for more power plants, transmission lines, distribution wires, and substantially reduce pollution levels. Sixth, the RTP gateway presents de-averaged electricity prices, and thus provides direct education to customers about the implications of their electricity use and opportunities to control their electricity bills. Seventh, customers armed with knowledge about electricity prices can dramatically reduce loads during system peaks, which will eliminate the need for plants that stand otherwise unused for the rest of the year. And eighth, electricity customers can directly, through their actions, counter rising fuel costs, access new energy services, use specific new technology, and mitigate the environmental impacts of electricity generation.

Conclusion

The WattSpot RTP program with its electronic gateway is an effective tool to leverage new technologies to provide manual and automated services that enable customers to have greater choice, such as to be price responsive. Residential customers that have and use internet access can benefit substantially from new electricity service gateways, particularly to control their bills and tap other energy technologies and services. Technology such as smart thermostats and appliance cycling further increase the benefits of price response and provide low-hassle automation for customers. Demand response through both RTP and TOU pricing has been much discussed as the panacea to resolve a host of electric industry issues. Both are now largely proven. Technology to expand customer choice provides the bridge to meet environmental objectives, increase grid reliability, increase customer satisfaction, and provide more accurate investment signals to guide system expansion. Thus, internet gateways and an array of new research and technology are poised to resolve vexing issues in competitive electricity markets and to further enable meaningful customer choice.

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